Final Report

Using Unmanned Aerial Vehicle (UAV) to detect wheat response to N fertilizers and fungicides

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Introduction

Wheat plots undergoing nitrogen and fungicide trials were flown to determine whether unmanned aerial systems (UAS or drones) can be used to detect stresses as they relate to nitrogen and disease.

Two fields were flown: a nitrogen trial and a fungicide efficacy trial. The nitrogen trial had 4 nitrogen rates (0, 40, 80 and 120 lbs/ac). The fungicide trials were intended to have displays of foliar and head diseases. Unfortunately, disease prevalence was not high in the plots. However, some promising results were found in the head disease plots.

Fungicide Efficacy and Palisade Trials

The fungicide efficacy plots were inoculated with 4 diseases:

- Fusarium Head Blight (Fusarium graminearum)
- Leaf Rust *(Puccinia triticina*)
- Septoria Leaf Spot (*Septoria titici*)
- Stagonospora Leaf Blotch (*Stagonospora nodorum*)

Detection of foliar diseases was low because the diseases did not show their usual coloration. Differences between plots did not follow with the expected consequences and the final changes in coloration did not manifest. This can be in the visible spectrum (RGB) image (Fig. 1) and especially in Figure 2, the image with the Red Vegetation Index (RVI) applied. In Fig. 2, the controls are denoted with a “C” and should all have a high value on the scale (above 1). However, the values vary, with one control being far below 1.

RGB Photo for Foliar Diseases:

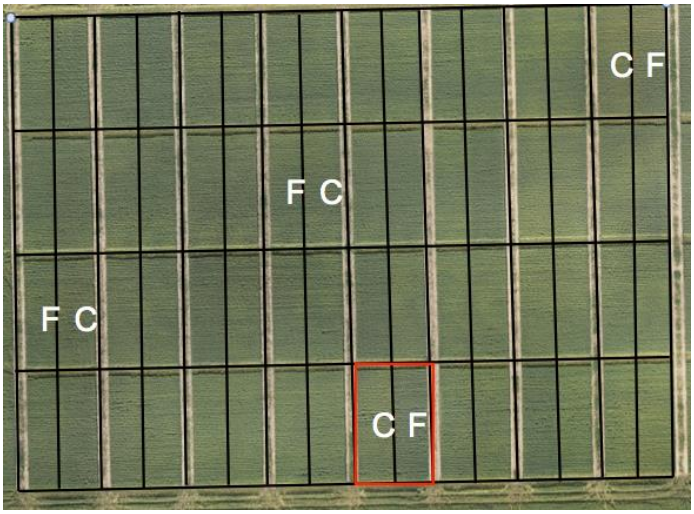

Figure 1: Taken on 6/27/14, this stitched photograph shows the visible differences between trials. Controls showed no consistent differences from treated plots, warranting more investigation.

Red Vegetation Index (RVI) of Foliar Diseases:

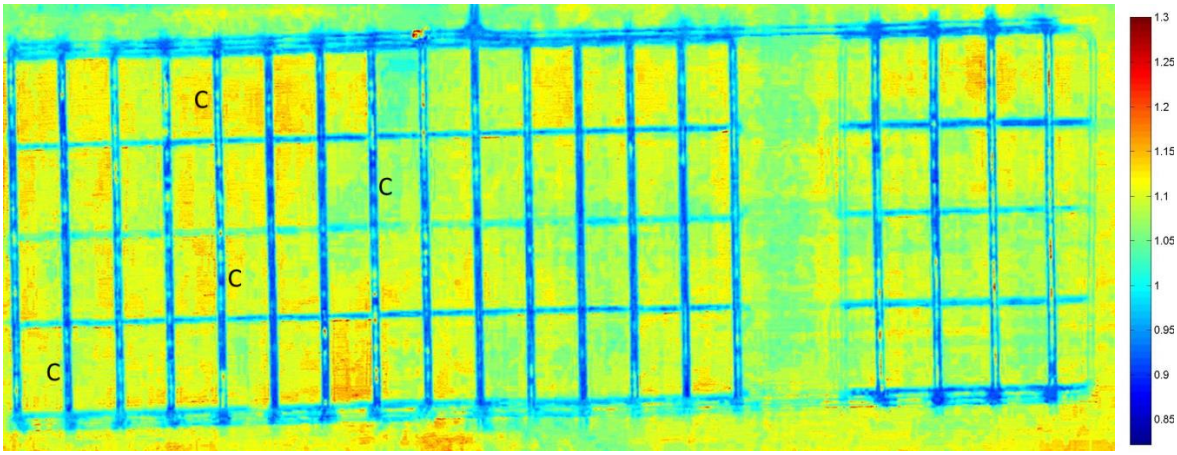

Figure 2: Application of the Red Vegetation Index to Figure 1. On the scale, values above 1 (warmer colors) denote areas where there is more green than red. Areas with more red than green have values below 1 (colder colors).

In the head blight plots, enough disease occurred to experiment with detection at various heights. It was found that the drone could detect a diseased wheat head flying at 15 meters altitude and looking at a 45 degree angle. Figure 3 is an example of such an image. In this image, a single head is circled by two hoops (blue and pink) in the field. Later, a red circle was digitally added round the head based on field notes and images. By using the RVI, it was possible to make this single head stand out (Fig. 4). It is expected that using the same index will

make it possible to give a score of disease prevalence in a field. However, more work will need to be conducted at a larger scale to test this concept.

Head Blight Visual Image:

Figure 3: Image of wheat head with fusarium head blight and hoops placed around the head from identification made on the ground.

RVI of Head Blight Image

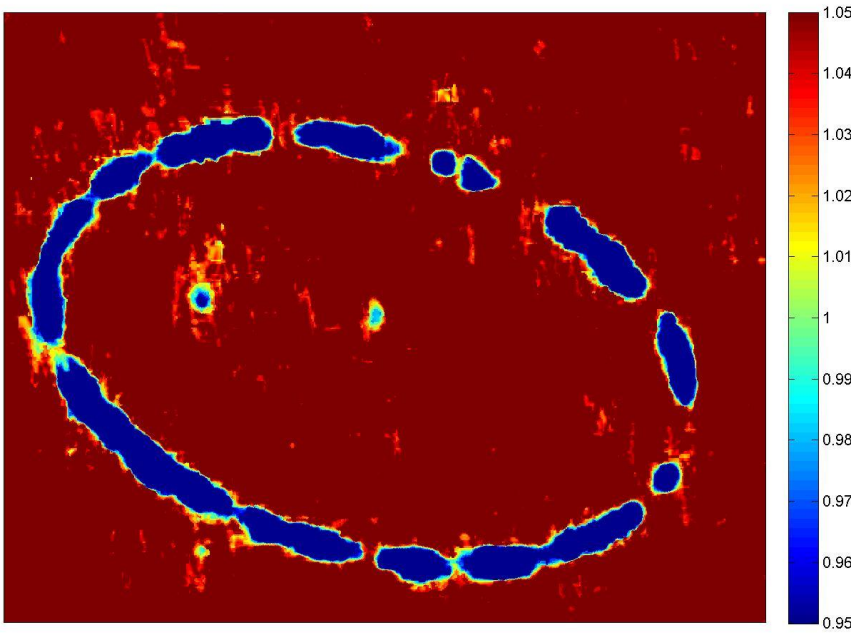

Figure 4: By constraining the RVI values, the head blight stands out, along with the pink hoop (appears blue here) and the white label of the lower hoop (left of diseased head).

Alongside the fungicide plot was significant winter damage. Figure 5 shows how drones could be used as scouting tools to find and quantify these areas. The same could be done with lodging (Fig. 6).

Winter Freeze Damage:

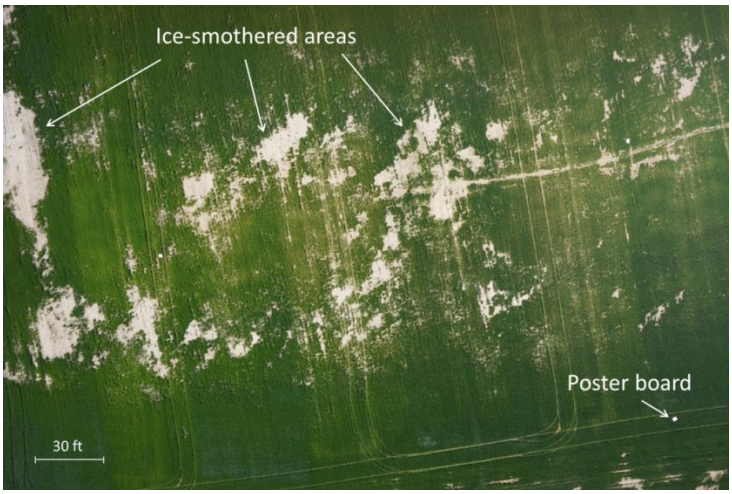

Figure 5: Taken on 5/31/14, areas with winter damage are clearly visible and potentially quantifiable.

Lodging:

Figure 6: Taken on 7/10/14, areas with lodging are also clearly visible and potentially quantifiable.

Nitrogen Trials

In the nitrogen trials, visual differences appeared as expected: in general, plots with more nitrogen showed up as greener than those with less nitrogen. This was complicated to some degree by large differences in topography and soil moisture within the plot. Even so, Figure 7 shows the visual differences, which stand out even more in Figure 8. However, little distinction can be made between the higher rates (80 and 120 lbs/ac), suggesting that 80 lbs/ac might have been the optimal rate of application, or more likely that the plots with 80 lbs/ac were not running into nitrogen deficiencies by the date of the flight. In fact, later flights did show a difference between 80 and 120 lbs/ac, but the early images are shown here because the flights were at a date, May 30th, when additional applications of nitrogen would still be practical, and while a grower might not be able to tell differences between the higher rates, they will be able to see areas that were skipped in the application of fertilizer.

RGB Photo of Nitrogen Trial:

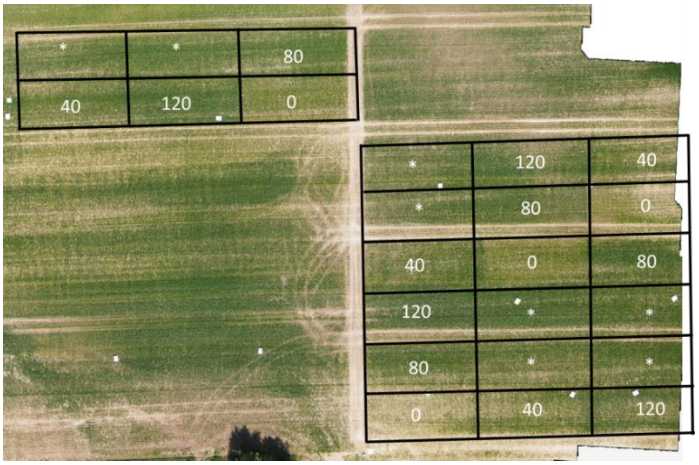

Figure 7: Taken on 5/30/14, different N treatments (lbs/ac) are visible to the eye. Note: asterisks denote plots that were part of a different field experiment.

RVI of Nitrogen Trial:

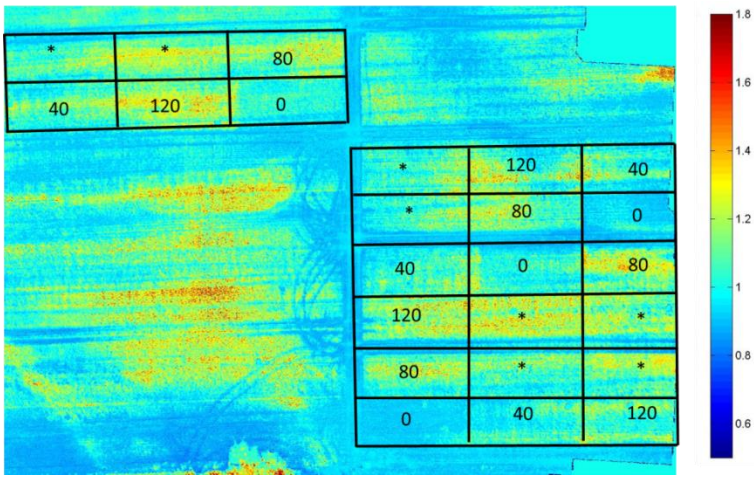

Figure 8: The RVI shows high contrast between the different N treatments at a time when a second application of fertilizer might still be practical (spring application was 19 days earlier, on 5/11/14).

Conclusion

Drones fitted with a normal visible spectrum camera are capable of detecting diseased heads in wheat, along with nitrogen application differences. This is valuable knowledge because these simple approaches will be some of the most affordable and therefore are likely to be some of the earliest adopted.